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Mealybugs of Santa Cruz Island, California¹

(Homoptera: Coccoidea: Pseudococcidae)

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The purpose of this paper is to discuss the mealybugs of Santa Cruz Island. By examining the distribution patterns of mainland pseudococcids and by reviewing studies of other parts of the California insular biota, it has been possible to locate likely sources of the Santa Cruz Island mealybug fauna.

There are 16 major islands along the Baja California-southern California coast which are normally called the California Islands; these islands are divided into three groups. Those off the coast of Baja California are the Baja California Islands, those off the coast of California

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from Point Conception to San Diego are the Southern Channel Islands, and those off the coast near the town of Oxnard are the Northern Channel Islands. The Northern and Southern Channel Islands are collectively called the Southern California Islands (Philbrick, 1967).

This paper is primarily concerned with the Northern Channel Islands. From east to west the four islands comprising this group are: Anacapa, with three islets, Santa Cruz, Santa Rosa, and San Miguel.

THE CALIFORNIA ISLAND BIOTA

The fauna and flora of the Northern Channel Islands is basically the same as that of the adjacent mainland; however, there are several notable exceptions. First, there is a surprisingly large number of endemics considering that the islands have been separated from the mainland only since the mid-Pleistocene (Valentine and Lipps, 1967; Axelrod, 1967) and are presently only 13 miles from the nearest point on the mainland (Philbrick, 1967). Second, components of the Northern Channel Island biota show striking affinities with biotas either far to the north or to the south on the mainland.

Although the percent of endemism on the California Islands is relatively low, endemic forms are known throughout most of the carefully studied groups of plants and animals. Among scientists there is disagreement regarding the source of this endemism. Some believe that the endemics have evolved on the islands themselves, while others think that the islands, with their moderate climates, are relictual areas of previously more widely dispersed species. It is now apparent that the majority of the endemics are of relictual origin. Axelrod (1967) pointed out that in the past most of the woody endemics occurred rather extensively on the mainland. However, there are still a few examples of endemics which are not easily explained by the refugia concept. The divergent forms of the tarweed genus *Hemizonia* (Carlquist, 1965) and the concentration of dwarf and giant endemics on the islands, appear to be examples of divergent endemism. It is likely therefore that both sources of endemism have added to the California insular biota with relictual endemism being the more predominant type.

Disjunct distribution patterns are also of interest. A number of the California insular vascular plants are distributed on the mainland in areas which are not adjacent to the islands where they occur (Raven, 1967). On the Northern Channel Islands these affinities are mainly with biotas which occur at least 100 miles to the north. A few cases of affinities to the south are also known.

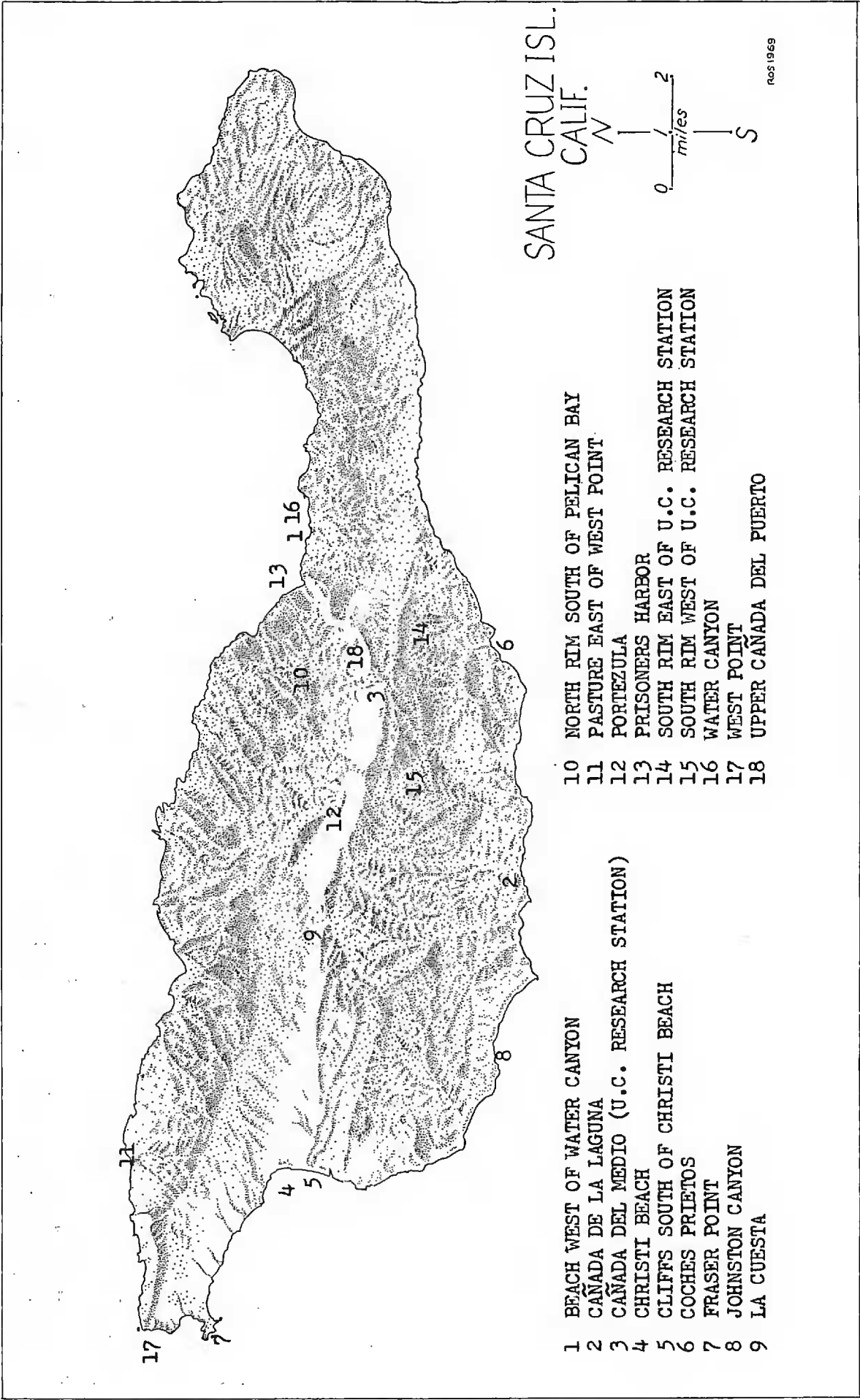
The presence of northern and southern components within the extant

flora of a single island has been best explained by Axelrod (1967). He believes that during the last glacial period the flora of the coastal areas of southern California was most similar to the present flora of Monterey, approximately 200 miles to the north of Santa Cruz Island. A warming trend, called the Xerothermic period, followed this glaciation and allowed a more arid flora to become predominant. The previous flora receded northward leaving only remnant populations in localized pockets which remained favorable. The more moderate and moist climates of the islands apparently favored these remnants. Approximately 5,000 years later the climate gradually became more moist and the Xerothermic period ended. The arid flora was pushed southward and inland leaving remnants along the coast and on the islands. Therefore the present insular biotas possess components which are allied to both northern and southern mainland elements.

SANTA CRUZ ISLAND

From a zoogeographical standpoint, Santa Cruz is probably the most interesting of the Northern Channel Islands. Of the four islands comprising this group, Santa Cruz is the largest in land area (Philbrick, 1967), has apparently been land-positive for the longest period of time (Weaver and Doerner, 1967), and probably has the greatest potential for ecological diversity (i.e., diversity in soil type, climate, and elevation). For these reasons the biota of Santa Cruz is most likely to give clues to the past history of the Northern Channel Islands.

Santa Cruz Island is diverse ecologically. Most of its shoreline is made up of steep cliffs, but stream beds which dissect the coastline frequently support small coastal beaches of sand or smooth, surf worn rocks, or of both. Larger beaches are also present, particularly on the southwest end of the island. Deep canyons and rugged hillsides are the predominant surface features; the highest peak is over 2,400 feet. The center of the island supports a linear series of wide valleys formed on a fault which runs along the east-west axis of the island. It is this series of valleys which adds to the diversity of Santa Cruz. Frequently when the coastal areas are windy or covered with fog, the central valley is clear and nearly wind free. Thus, the inland areas are climatically quite different from the coast. The rapid changes in habitats which one experiences on the island are startling. Within its confines I traveled to dense oak groves, open grasslands, pine forests, cactus laden hillsides, dense chaparral areas, barren ridges, wind blown beaches, protected lagoons, steep canyons, open valleys, shingle beaches, permanent freshwater streams, and coastal cliffs.



MAP 1. Santa Cruz Island mealybug collection sites.

The insect fauna of Santa Cruz Island, until recently, has been poorly known. Dr. Carey Stanton, present owner of most of the island, has encouraged scientific studies on Santa Cruz and has allowed the University of California to establish a research station for this purpose. Given this opportunity, entomologists from the Berkeley, Davis, and Riverside campuses have undertaken survey expeditions. I have been fortunate to participate in three trips, and although this paper must be considered preliminary, it probably includes a majority of the mealybug species which occur on the island.

SCALE INSECTS AND PLANTS

There are some notable similarities between the habits of scale insects (Coccoidea) and plants in regard to dispersibility. Female scales are generally sedentary. The eggs are normally covered either by the body of the female or by a waxy secretion produced by her. First instar nymphs of both sexes are mobile, and although they are susceptible to long-range wind movements, they are probably best adapted for short-range dispersal to other parts of the parent plant or to adjacent plants. Once the first instar has settled, further movements are either nonexistent or quite unusual. With the exception of the first instar, the immature stages of the male are relatively sessile; movements in search of pupation sites may take place, but these are apparently very limited. The adult male is usually winged and apparently is adapted to long-range as well as short-range movements; it may carry genetic material to geographically isolated populations, but it cannot establish a new population. Movements of adult males are both active and passive. The presence of female sex pheromones (Tashiro and Chambers, 1967) would seem to confirm active movements of the male toward the female. Passive dispersal has not been conclusively established, but the presence of long caudal projections and a light body weight appear to be adaptations to enhance bouyancy for passive wind dispersal.

Plants have many of these characteristics. The primary portion of most plants with the attached female reproductive system is sessile. Seeds usually are enclosed within other plant tissues. Although some seeds are capable of long-range passive dispersal, establishment in many instances occurs in areas adjacent to the parent plant; once established, movements are unlikely. Pollen can carry genetic material to geographically isolated populations, but it is not capable of establishing a new colony. The use of pollinators which actively seek out receptive reproductive parts in plants would seem to qualify as a type of active dispersal, whereas movements of pollen by wind clearly fit passive dispersal.

The similarities between plants and scale insects, though perhaps somewhat superficial, have encouraged me to search for correlation between the Santa Cruz Island flora and the scale insect fauna. On this island Raven (1967) records 31 endemic plants, including seven which are exclusively endemic and 24 which are present on Santa Cruz and at least one other California Island. Plants with disjunct distribution patterns and plants with restricted mainland populations are also present on Santa Cruz. Therefore, I had hoped to find these same characteristics within the scale insect fauna.

SANTA CRUZ ISLAND MEALYBUGS

I have restricted my attention to mealybugs because this group is the best known of the California scale insects, and because insular pseudococcids, of all the Coccidea, are normally the most distinctive.

The following list of the mealybugs known to occur on Santa Cruz Island includes 13 genera and 23 species. The localities may be found on the accompanying map. Plant names are presented as listed by Munz and Keck (1965).

Amonostherium

lichtensioides (Cockerell)

1. Coches Prietos, 18 June 1967, *Artemisia californica* (crown and foliage)
2. south rim east of U. C. Research Station, 9 May 1968, *A. californica* (foliage)

Anisococcus

quercus (Ehrhorn)

1. upper Cañada del Puerto, 27 April 1969, *Quercus agrifolia* (under bark and in duff beneath tree)

Chorizococcus

abroniae McKenzie

1. Christi Beach, 19 June 1967, *Amblyopappus pusillus*, *Franseria chamissonis*, *Mesembryanthemum crystallinum* (roots)

Discococcus

simplex Ferris

1. pasture east of West Point, 30 April 1969, *Sitanion* sp. (crown)

spectabilis McKenzie

1. Prisoners Harbor, 7 May 1968, *Bromus* sp. (roots)

Distichlicoccus

salinus (Cockerell)

1. Cañada de la Laguna, 30 April 1969, *Distichlis spicata* (leaf blade sheath)
2. Christi Beach, 5 May 1968 and 26 April 1969, *D. spicata* (on leaf blade)
3. mouth of Johnston Canyon, 21 June 1967, *D. spicata* (leaf blade sheath)

Heterococcus

arenae Ferris

1. Cañada del Medio, U. C. Research Station, 16 June 1967, *Festuca* sp. (leaf blade sheath)

2. Cascada, 4 May 1968, grass (leaf blade sheath)
3. Coches Prietos, 18 June 1967, *Festuca* sp. (leaf blade sheath)
4. south rim west of U. C. Research Station, 6 May 1968, grass (leaf blade sheath)

*Paludicoccus**distichlium* (Kuwana)

1. Christi Beach, 5 May 1968, *Distichlis spicata* (crown)

*Phenacoccus**colemani* Ehrhorn

1. north rim south of Pelican Bay, 3 May 1969, *Garrya* sp. (undersides of leaves)

eriogoni Ferris

1. Prisoners Harbor, 7 May 1968, *Eriogonum latifolium* (stems)

eschscholtziae McKenzie

1. Fraser Point, 11 May 1968, *Haplopappus venetus* (roots)

gossypii (Townsend and Cockerell)

1. Cañada del Medio, U. C. Research Station, 17 June 1967, *Eschscholtzia californica* (crown and roots)

solani Ferris

1. Fraser Point, 11 May 1968, *Mesembryanthemum nodiflorum* (roots)

*Pseudococcus**beardsleyi* Miller and McKenzie

1. north rim south of Pelican Bay, 3 May 1969, *Arctostaphylos subcordata* (foliage)
2. south rim west of U. C. Research Station, 18 June 1967, *A. subcordata* (foliage)

longisetosus Ferris

1. Cañada del Medio, U. C. Research Station, 7 May 1968, *Rhus diversiloba* (roots)

obscurus Essig

1. cliffs south of Christi Beach, 26 April 1969, *Castilleja* sp. (crown)
2. La Cuesta, 5 May 1968, *Eriogonum latifolium grande* (crown)

*Puto**yuccae* (Coquillett)

1. beach west of Water Canyon outlet, 2 May 1969, *Eriogonum* sp. (roots)
2. Christi Beach, 19 June 1967, 5 March 1968, and 5 May 1968, *Amblyopappus pusillus*, *Atriplex semibaccata*, *Chenopodium* sp., *Eriogonum* sp., and *Haplopappus venetus* (roots, crown, and foliage)
3. Portezuela, 20 June 1967, soil
4. Water canyon (500 ft.), 17 June 1967, *Diplacus longiflorus* and *Zauschneria cana* (foliage)

*Rhizoecus**bicirculus* McKenzie

1. south rim east of U. C. Research Station, 9 May 1968, grass (roots)
2. south rim west of U. C. Research Station, 6 May 1968, *Lotus scoparius* (roots)

gracilis McKenzie

1. Coches Prietos, 18 June 1967 and 10 May 1968, *Artemisia californica* and *Haplopappus canus* (roots)

leucosomus (Cockerell)

1. Coches Prietos, 10 May 1968, *Dudleya greenii* (roots)

Spilococcus

keiferi McKenzie

1. beach west of Water Canyon outlet, 2 May 1969, *Eriogonum* sp. (roots)

Trionymus

caricis McConnell

1. Christi Beach, 26 April 1969, *Distichlis spicata* (leaf blade sheath).

utahensis (Cockerell)

1. Cañada de la Laguna, 30 April 1969, *Bromus* sp. (leaf blade sheath)
2. mouth of Johnston Canyon, 21 June 1967, *Avena* sp. (leaf blade sheath)

There appears to be an unusually small number of pseudococcids on Santa Cruz Island. This is difficult to quantify, but as an indication, when collecting in the coastal areas of southern California, it is exceedingly unusual to find less than ten lots of mealybugs per day whereas, on the island I was never able to find more than four. In addition, McKenzie (1967) lists approximately 53 species of mealybugs which probably occur in the coastal areas near Oxnard and which have been collected on hosts that occur on Santa Cruz Island. Of these 53 species, only 23 are known to occur on Santa Cruz. Therefore, not only are there a small number of mealybug species on Santa Cruz, but these species appear to be sparsely distributed.

All mealybugs that occur on Santa Cruz Island have been recorded from the California mainland. Nine of the 23 species present on the island are distributed throughout most of continental California, five of the 23 species occur exclusively in the coastal mountain ranges, two occur in the coastal ranges and the southern California deserts, two in the coastal ranges and the beaches, one in the coastal ranges and the Cascade Mountains, one exclusively on beaches, one in the Trinity Alps, and two occur in the saline regions along the coast. These data suggest that the majority of the mealybugs which occur on Santa Cruz Island are most closely allied to the aggregation of pseudococcids which are present in coastal areas on the mainland. The presence of a small number of desert and northern mountain species suggest the displacement of previous northern and southern mealybug faunas. These data are consistent with the findings of botanists.

Although mealybug collecting on Santa Cruz has not been extensive enough to give detailed distribution patterns, it appears that the pseudococcids show no unusual ecological diversity. As far as can be determined, none of the species occur on hosts or in habitats which are radically dif-

ferent (i.e., species which occur on mainland beaches occur on island beaches).

Perhaps the most interesting aspect of the Santa Cruz Island mealybug fauna is found among the species which show disjunct distribution patterns. They are as follows:

Mealybug	Southernmost mainland locality	Approximate distance north from Oxnard
<i>Anisococcus quercus</i>	Mountain View, Santa Clara Co.	275 miles
<i>Discococcus simplex</i>	San Miguel, San Luis Obispo Co.	135
<i>Pseudococcus longisetosus</i>	Pacific Grove, Monterey Co.	225
<i>Rhizoecus bicirculus</i>	Weaverville, Trinity Co.	480
<i>Trionymus caricis</i>	Patterson, Stanislaus Co.	250

Although only five pseudococcids show this pattern, it is significant that they are all northern disjunctions. This is consistent with the findings of Raven (1967) and Axelrod (1967), who indicate that the majority of the non-endemic Northern Channel Island plants which are not present on the adjacent mainland are present in northern California.

Pseudococcus beardsleyi also shows an interesting distribution pattern, occurring in several small areas in the higher elevations of Santa Cruz Island and in similar areas at Pt. Reyes, Mt. Tamalpais, and Mt. Wilson on the mainland. The occurrence of this species in small, widely separated areas is reminiscent of the restricted distribution patterns of many plant relicts. It seems significant that Pt. Reyes, Mt. Tamalpais, and the upper elevations of Santa Cruz Island are inhabited by a number of these relicts and, in fact, could be considered refugia. Therefore, if *P. beardsleyi* is a relict pseudococcid, careful collecting in these refugia might reveal other interesting mealybug species.

SUMMARY

There are 13 genera and 23 species of mealybugs known on Santa Cruz Island none of which are endemic. The pseudococcid fauna of the island is a depauperate aggregation of species most like the mealybugs of the adjacent mainland, with a small representation of northern species. The majority of the Santa Cruz Island mealybugs have been previously re-

corded from the beaches or coastal mountain ranges on the California mainland.

There are both differences and similarities between the flora and the mealybug fauna of Santa Cruz Island. The most striking difference is the absence of endemic pseudococcids. It is possible that when the more distant Northern Channel Islands are examined, endemic forms will be discovered. Similarities are numerous. Both the flora and the mealybug fauna show close affinities to their respective counterparts on the adjacent mainland, both possess species with disjunct and restricted mainland distribution patterns, and both possess small components of northern and southern biotas.

ACKNOWLEDGMENTS

I gratefully acknowledge the assistance of Mr. Michael R. Benedict, Channel Island Field Station, University of California, not only for transporting me to the diverse areas of the island, but also for identifying most of the plant hosts.

Thanks are also due to Dr. Carey Stanton, owner of most of Santa Cruz Island, for permitting me to collect on his property. His encouragement of scientific studies on the island is commendable.

Mr. Robert O. Schuster, University of California, Davis, made available a copy of the map used in this paper and reviewed the manuscript.

Mr. Michael R. Benedict, Dr. Albert A. Grigarick, Dr. Donald S. Horning, Jr., Dr. Arnold S. Menke, Mr. Richard W. Rust, and Mr. Robert O. Schuster all collected specimens utilized in this study.

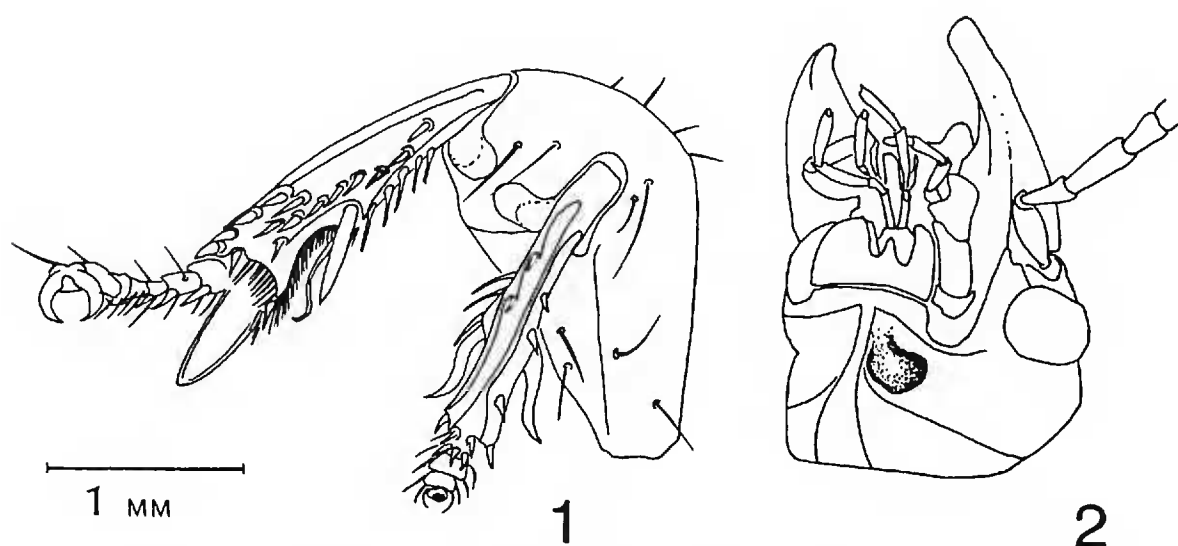
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SCIENTIFIC NOTE

A teratomorphic carabid beetle with notes on polymorphic asymmetry of the gular region in the same population (Coleoptera: Carabidae).—In a series of ten specimens of *Polpochila impressifrons* Dejean recently collected at Nova Teutonia, Brazil (January–February 1970, Fritz Plaumann) one female had a double tibia on the left anterior leg (Fig. 1). The more anteriorly placed tibia is perfectly formed while the posterior one is deformed, but nearly symmetrical. For example, the antennal comb spur is doubled and the cleaning setae are arranged in a straight row between the spurs. The tarsi on the deformed tibia are incomplete and the apical spur is doubled in laminate fashion.



FIGS. 1 and 2. *Polpochila impressifrons*. FIG. 1. Double tibia on left anterior leg of a female. FIG. 2. Fovea on venter of head of male.

In the same series of specimens, there is a total of 2 females and 8 males. Of the eight males, five have a deep comma-shaped fovea (Fig. 2) in the head capsule adjacent to the gula, but only on the right side (ventral aspect). One of the remaining males has a shallow depression there, while the other two males and the two females have no trace of this structure. Examination by means of a dissecting microscope (180 \times) did not reveal any sensory structures associated with the fovea and there does not seem to be any corresponding structure on the dorsum of the female, that is, a correlated structure with sexual functions (positioning, grip, etc.). Therefore, the function of this fovea or perhaps its accidental occurrence in some males must be studied further.—T. L. ERWIN, *Smithsonian Institution, Washington, D. C. 20560*.